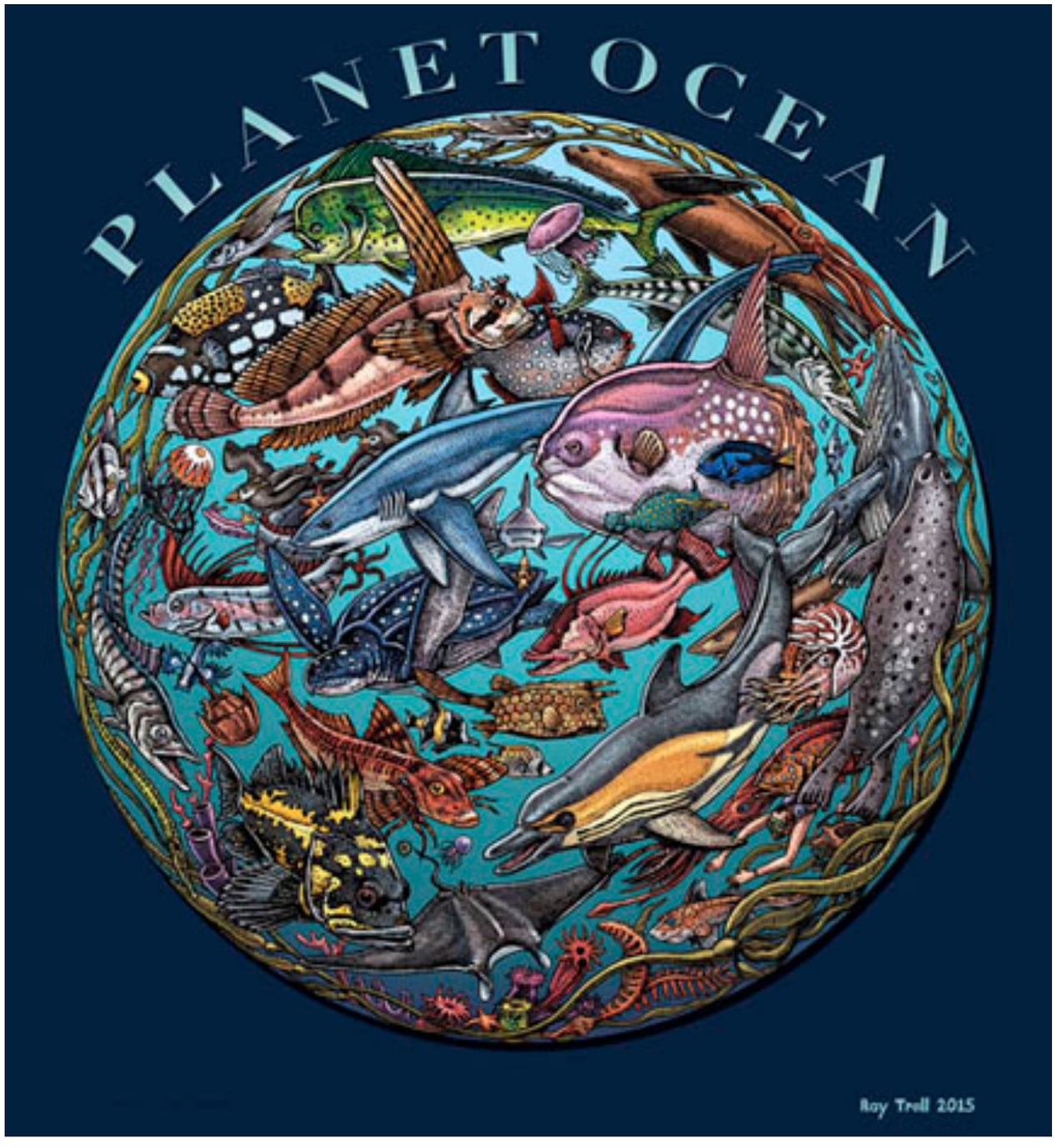
Santa Barbara Channel
Marine Biodiversity Observation Network



BOEM
Bureau of Ocean Energy Management

T.G.I. TROLL GLOBAL INDUSTRIES SCIENCE ART & MYSTERY

Marine Science Institute
University of California Santa Barbara

Who we are

Principal/Associate Investigators

Marine Science Institute
Robert Miller, Andrew Rassweiler, Daniel Reed, Milton Love

Ecology Evolution and Marine Biology
Craig Carlson, Deborah Iglesias-Rodriguez, Doug McCauley

Geography
David Siegel, Phaedon Kyriakidis

Electrical and Computer Engineering
BS Manjunath

USGS
Kevin Lafferty

UCSD - SIO
John Hildebrand

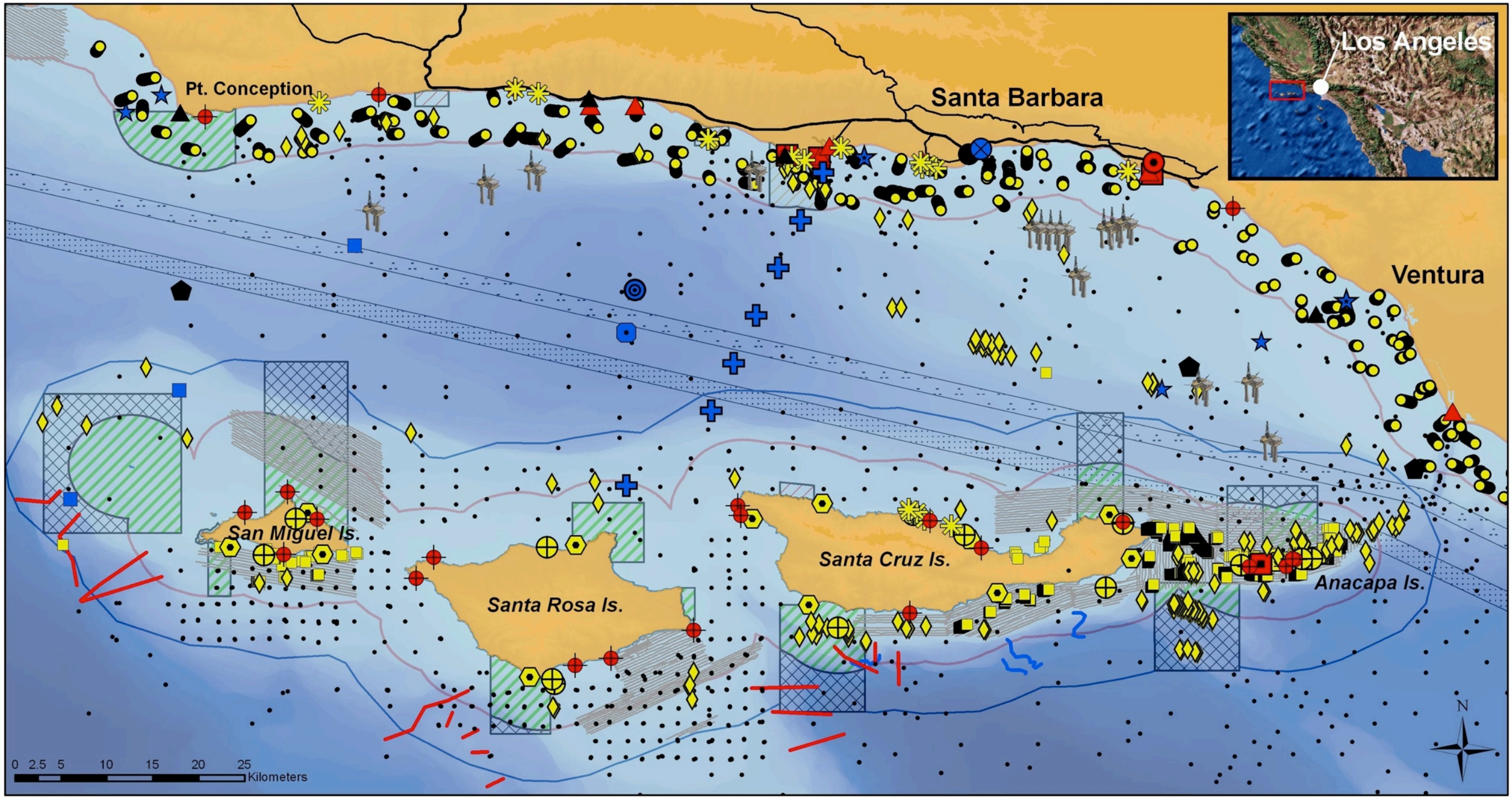
NOAA – NMFS SWFSC
Andrew Thompson

Partners

Channel Islands National Marine Sanctuary
Channel Islands National Park
Santa Barbara Coastal Long Term Ecological Research Program
Plumes and Blooms
Southern California Coastal Water Research Project
Southern California Coastal Ocean Observing System (SCCOOS)
Gray Whales Count
San Onofre Nuclear Generating Station Mitigation Monitoring
CalCOFI

Existing Monitoring Partners

Santa Barbara Channel, California



Legend

- CalCOFI
- CalCOFI / SCCOOS
- NOAA NMFS Midwater Trawls
- Mark VI Sediment Trap
- SIO Whale Acoustics
- SCCOOS HAB Monitoring
- Plumes and Blooms
- SCCOOS CDIP Buoy
- SCCOOS HF Radar
- SCCOOS Manual Shore Station
- SCCOOS Automated Shore Station
- LiMPETS Rocky Intertidal
- LiMPETS Beach
- SONGS Estuary Monitoring
- CINP/MARINe Rocky Intertidal
- Love Submersible Survey
- SBC LTER
- CNIP Kelp Forest
- CINMS OB Moorings
- USGS ROV Video
- USGS Scuba-ROV Surveys
- Love Oil Platform Survey
- USGS Sediment Samples
- USGS Survey Tracks
- CINMS Deep Sea Coral Transects
- CINMS OE Transects
- CA State Water
- Federal MPA
- CINMS Boundary
- Shipping North
- Shipping South
- SMCA
- SMCA (No-Take)
- SMP
- SMR
- SMRMA
- Special Closure

Bathymetry
Depth (m)
0
-1939

Projection: NAD 1983

Blue = Pelagic, Black = Oceanography, Red = Intertidal, Yellow = Benthic/Subtidal

CalCOFI - California Cooperative Oceanic Fisheries Investigations
SCCOOS - Southern California Coastal Ocean Observing System
NOAA - National Oceanic & Atmospheric Administration
NMFS - National Marine Fisheries Service
SIO - Scripps Institute of Oceanography
HAB - Harmful Algal Blooms
CDIP - Coastal Data Information Program
HF - High Frequency
LiMPETS - Long-term Monitoring Program & Experimental Training for Students
SONGS - San Onofre Nuclear Generating Station
SBC LTER - Santa Barbara Coastal Long-term Ecological Research
CNIP - Channel Islands National Park
MARINe - Multi-Agency Rocky Intertidal Network
CINMS - Channel Islands National Marine Sanctuary
ROV - Remotely Operated Vehicle
USGS - United States Geologic Survey
MPA - Marine Protected Area
SMCA - State Marine Conservation Area
SMP - State Marine Park
SMR - State Marine Reserve
SMRMA - State Marine Recreational Management Area

SANTA BARBARA CHANNEL (SBC) BON

Goals:

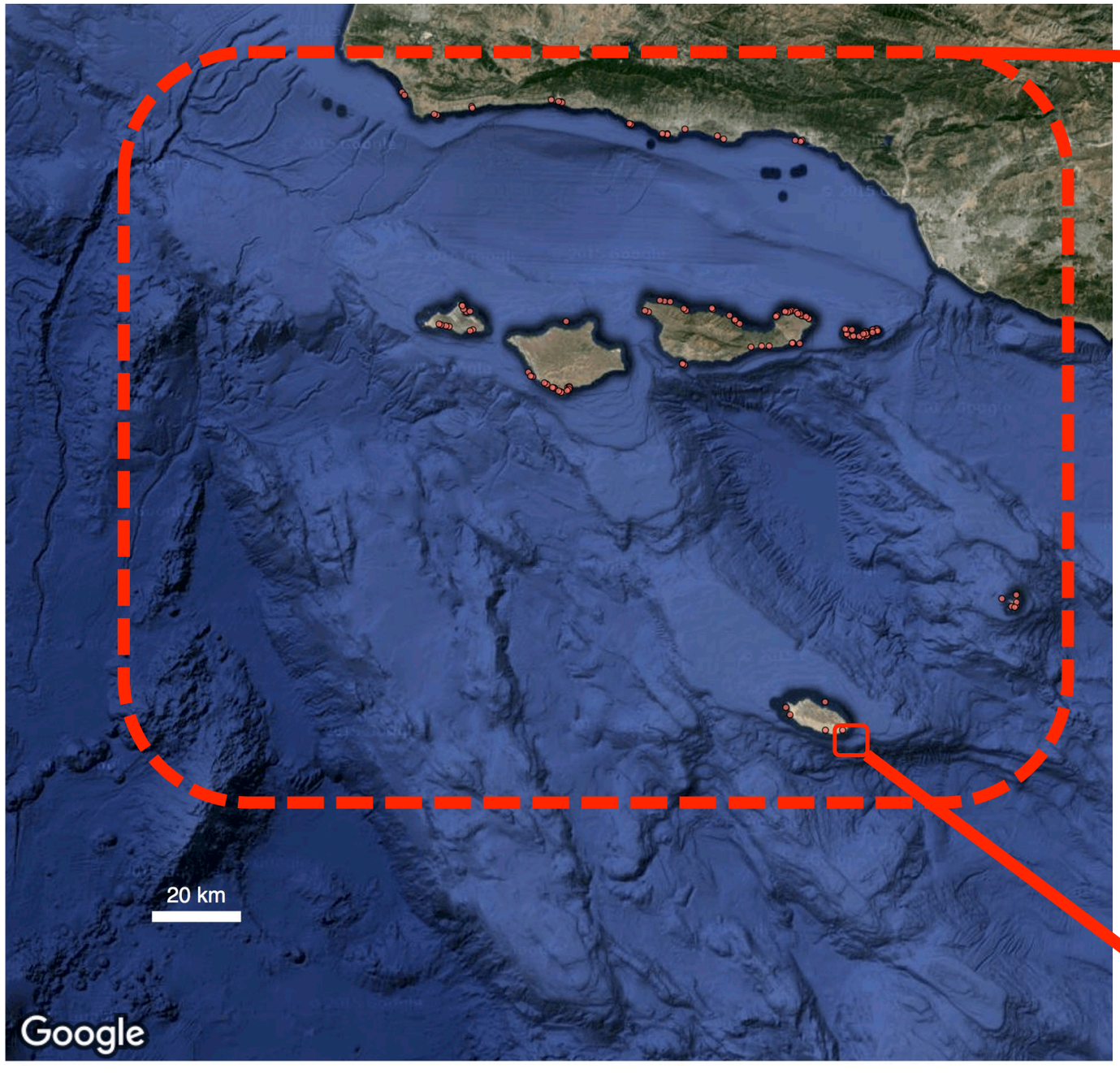
1. Integrate biodiversity data to enable inferences about regional biodiversity

2. Develop advanced methods in optical and acoustic imaging and genomics for monitoring biodiversity in partnership with ongoing monitoring and research programs

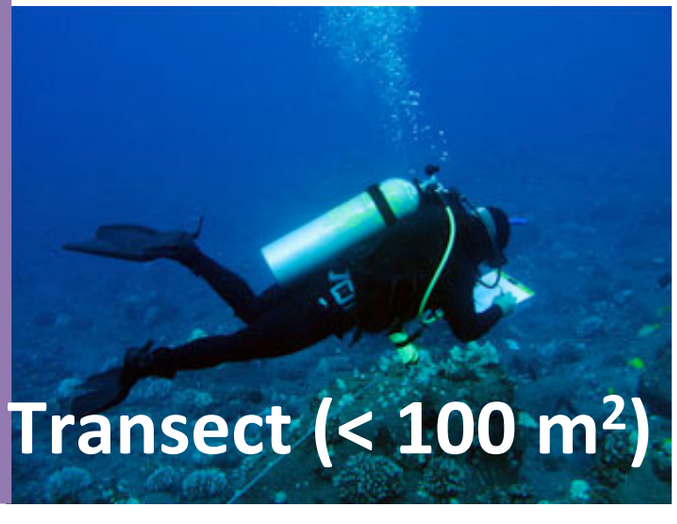
3. Implement a tradeoff framework that optimizes allocation of sampling effort

Complex and multiscale patterns of community structure

Communities are spatially structured at **multiple scales**. The spatial variation in community composition is **beta diversity**



Scaling with space



variation in community composition

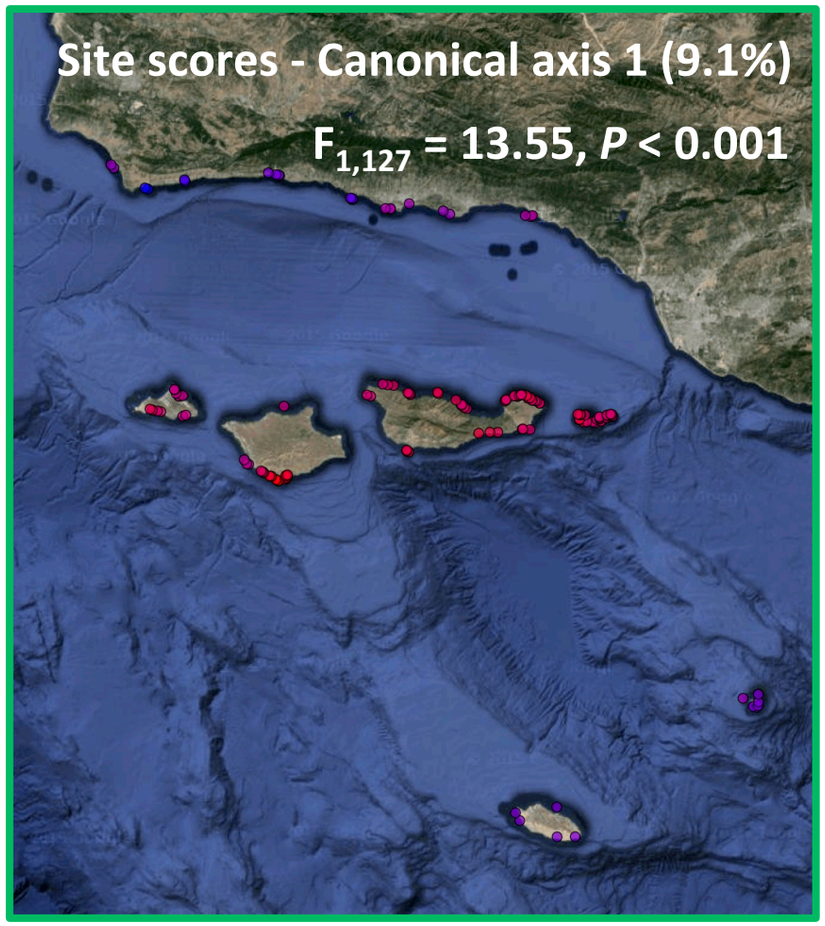
38% — Biogeographic trend

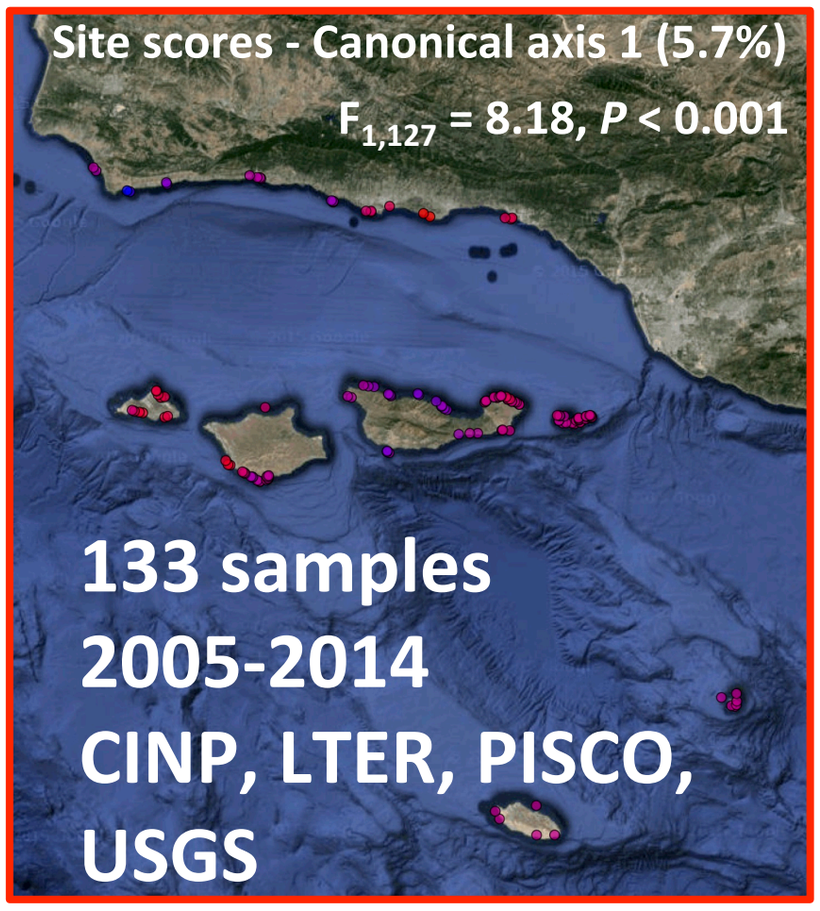
11% — Positive spatial structures

7% — Negative spatial structures

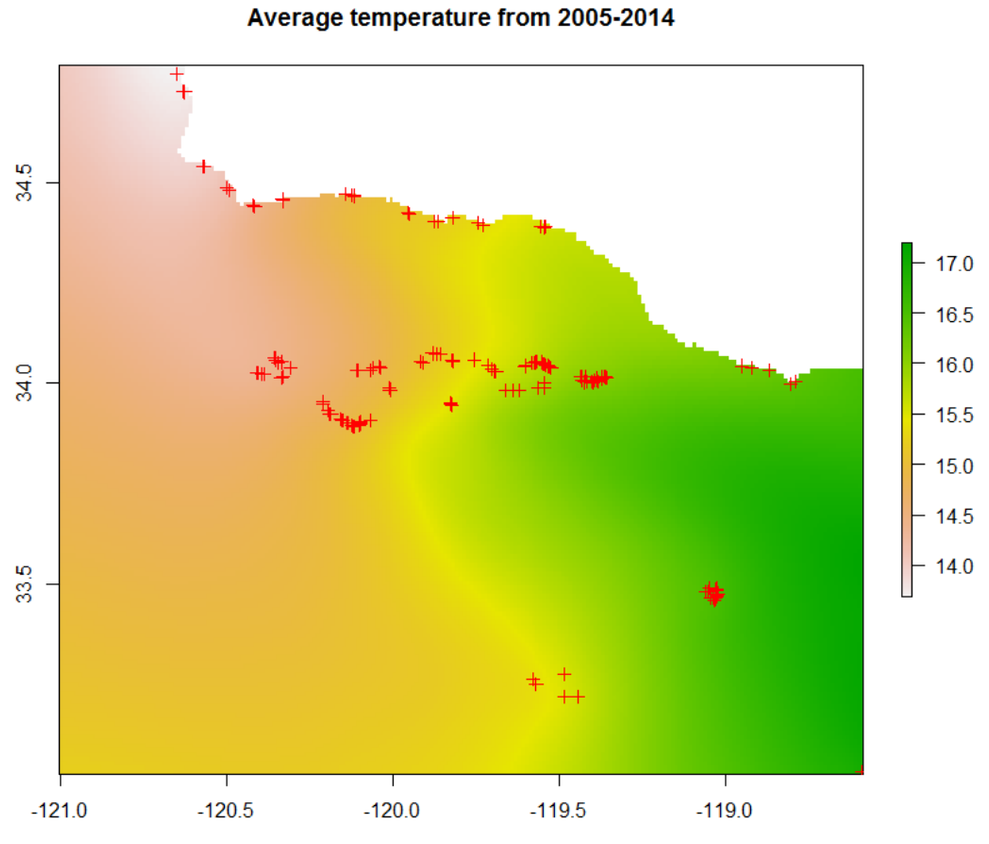
44% — Random noise (error)

Lamy et al., in prep





What are the ecological processes and environmental drivers underlying each of these scales?



Identifying environmental drivers

- Physical environment (SST, Bathymetry, substrate, slope)
- Pelagic primary production (Chl *a*)
- Benthic primary production (Kelp biomass)
- Disturbance regime (wave height, ENSO)
- Connectivity - source and destination strength

Landsat Kelp Forest Biomass

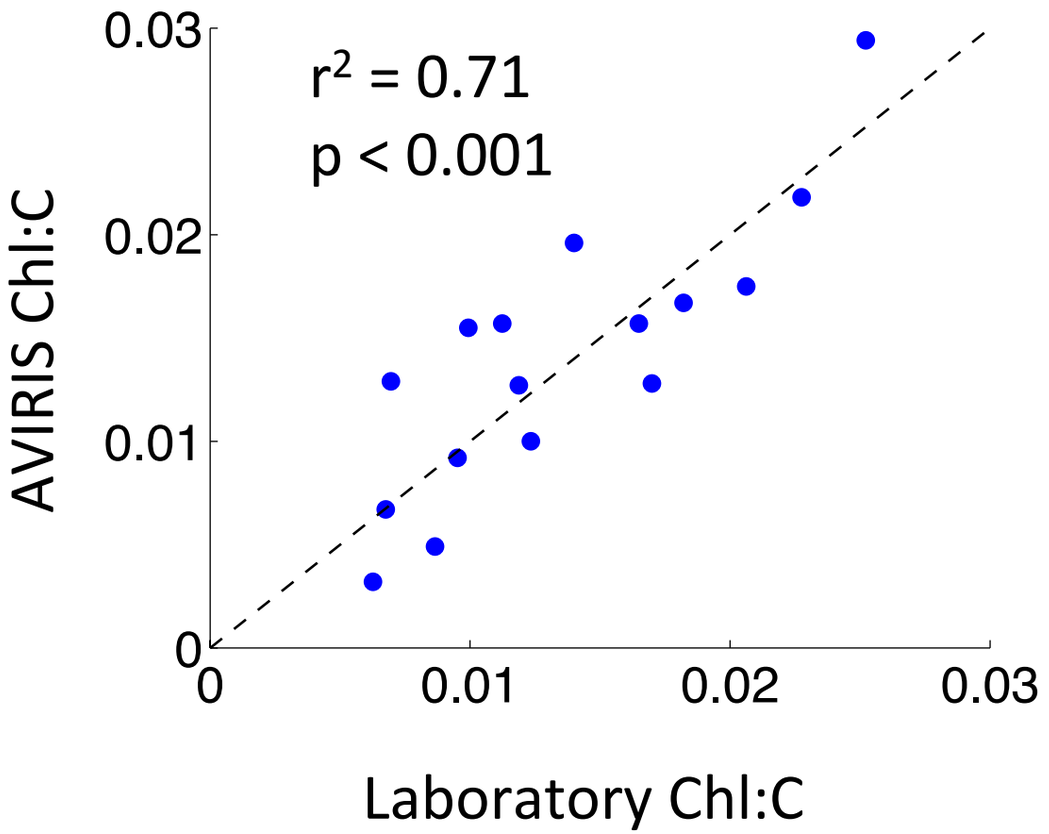
- 30 m resolution multispectral imagery
- Kelp reflectance calibrated to biomass measured by divers in SBC LTER long-term plots
- SBC time series includes ~ 6-8 usable images per year since 1984 from central CA to Baja CA

Canopy biomass of *Macrocystis pyrifera* (top) can be quantified from Landsat 5 imagery (bottom).

Hyperspectral aerial flights conducted 3x year^{-1} in 2013 – 2015 using the AVIRIS sensor in HysplRI preparatory campaign

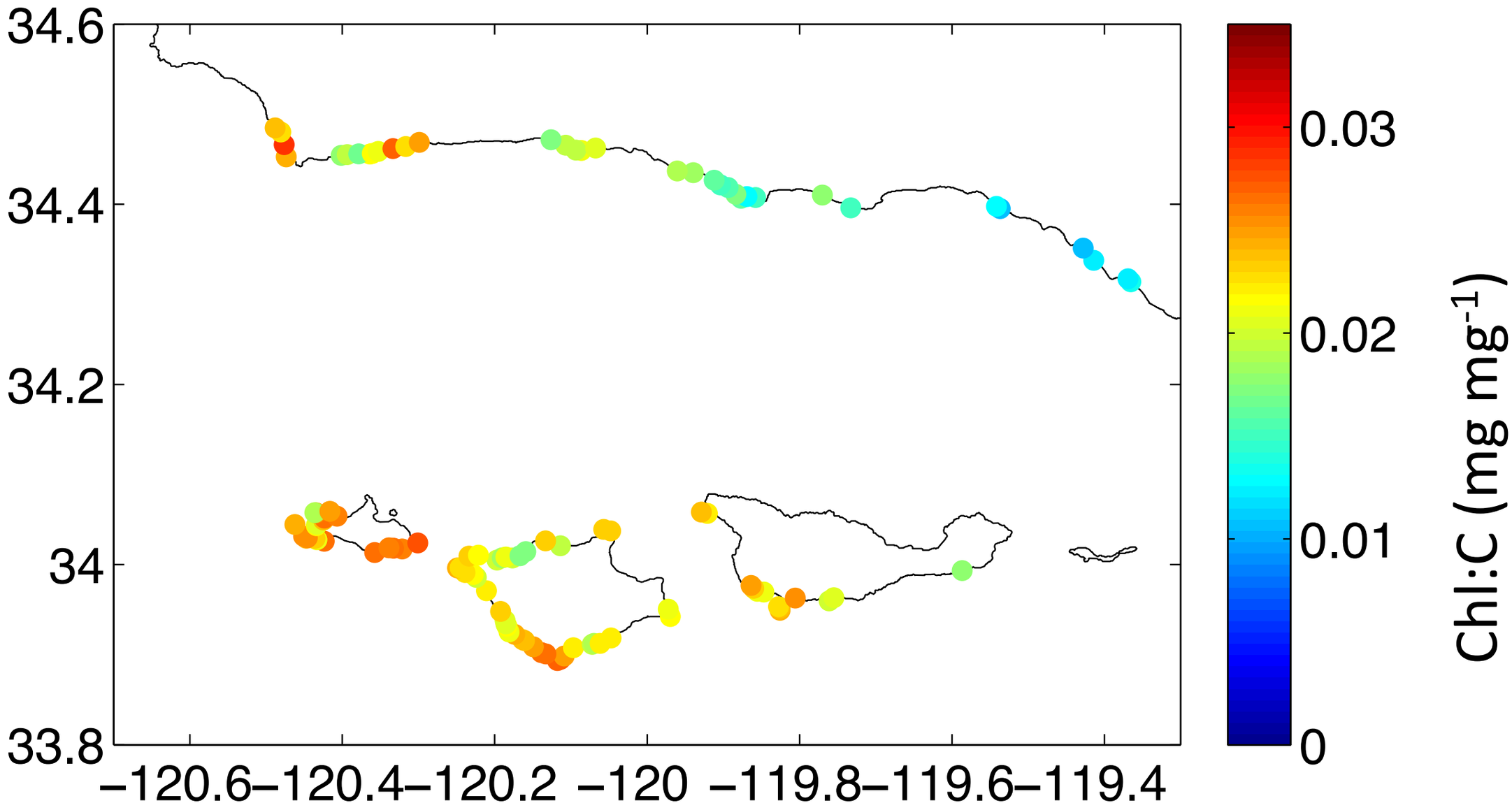
Thomas Bell, David Siegel

Chl:C estimated from hyperspectral images closely resembles Chl:C measured in the laboratory



Regional patterns of kelp Chlorophyll mirror the east-west gradient of temperature and nutrients in the Santa Barbara Channel

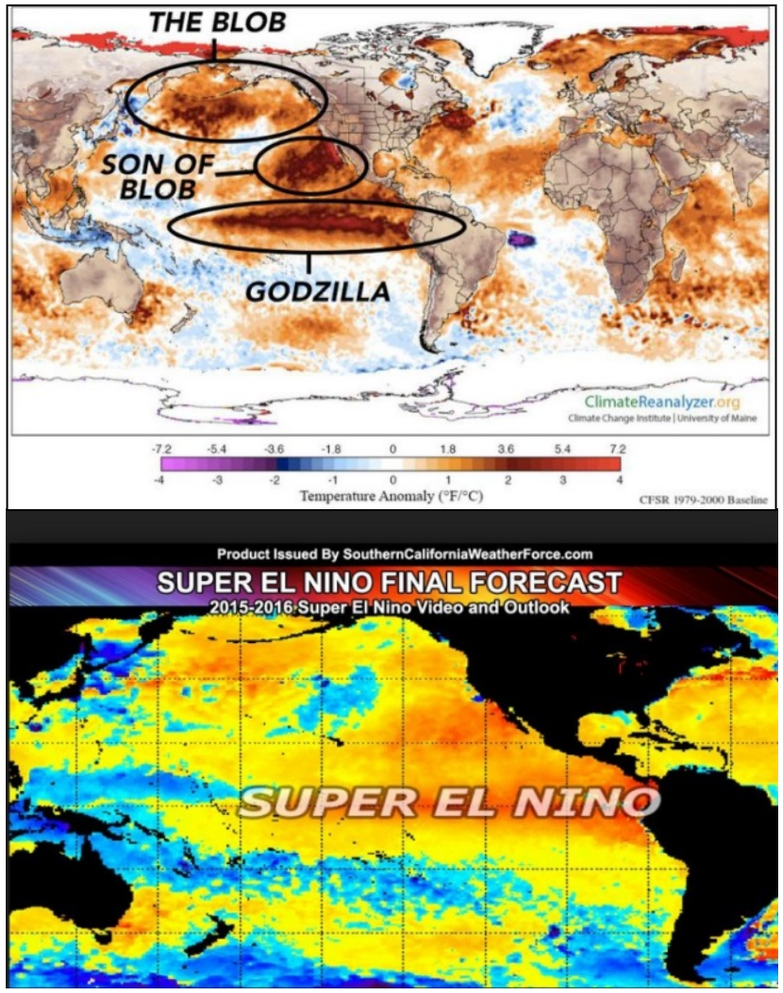
Physiological Condition of Giant Kelp Canopy June 2015

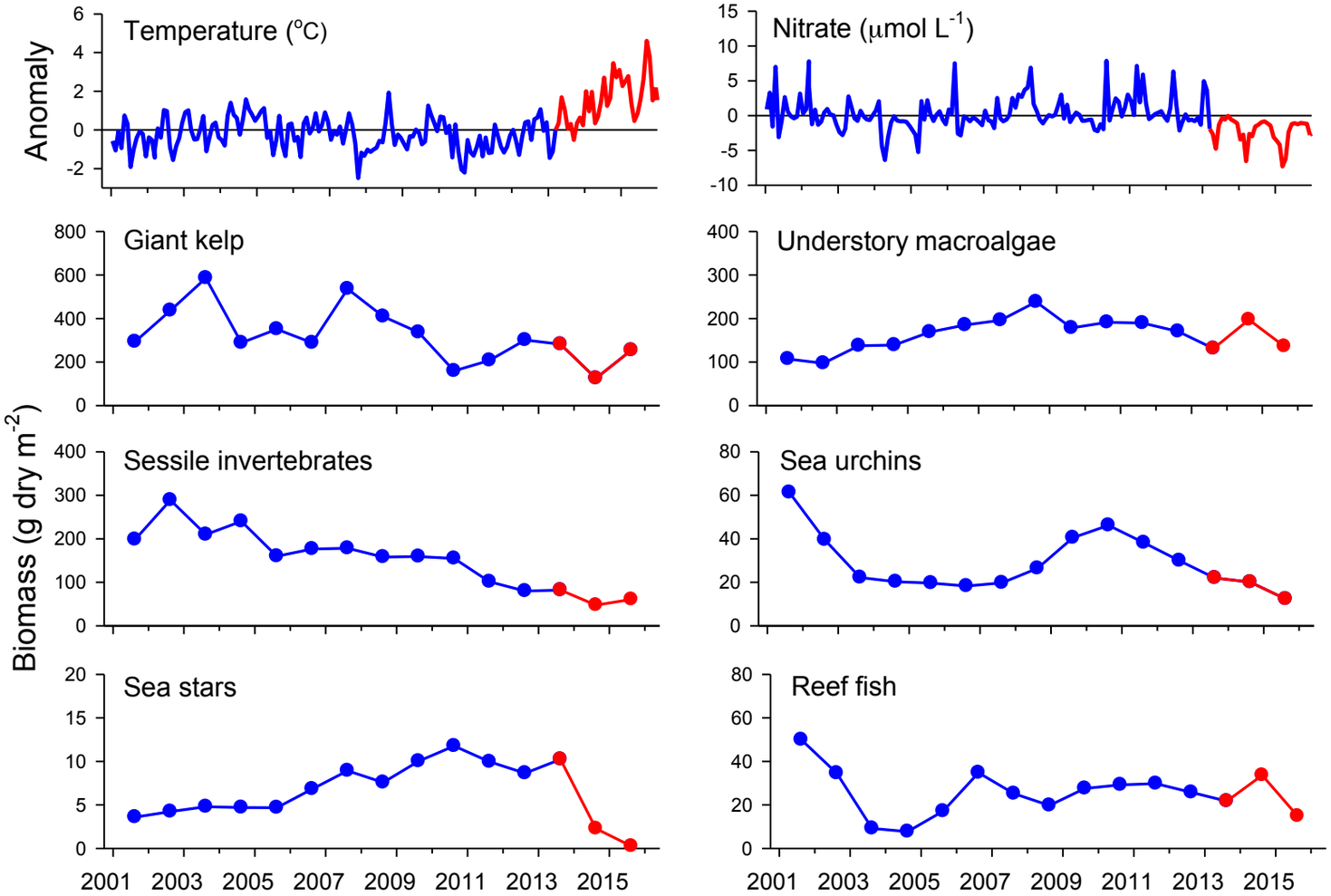


Bell et al. 2015

Responses of kelp forest ecosystems to climate change

Extreme warming event allowed us to test IPCC predictions of kelp forest decline in response to sea temperature extremes



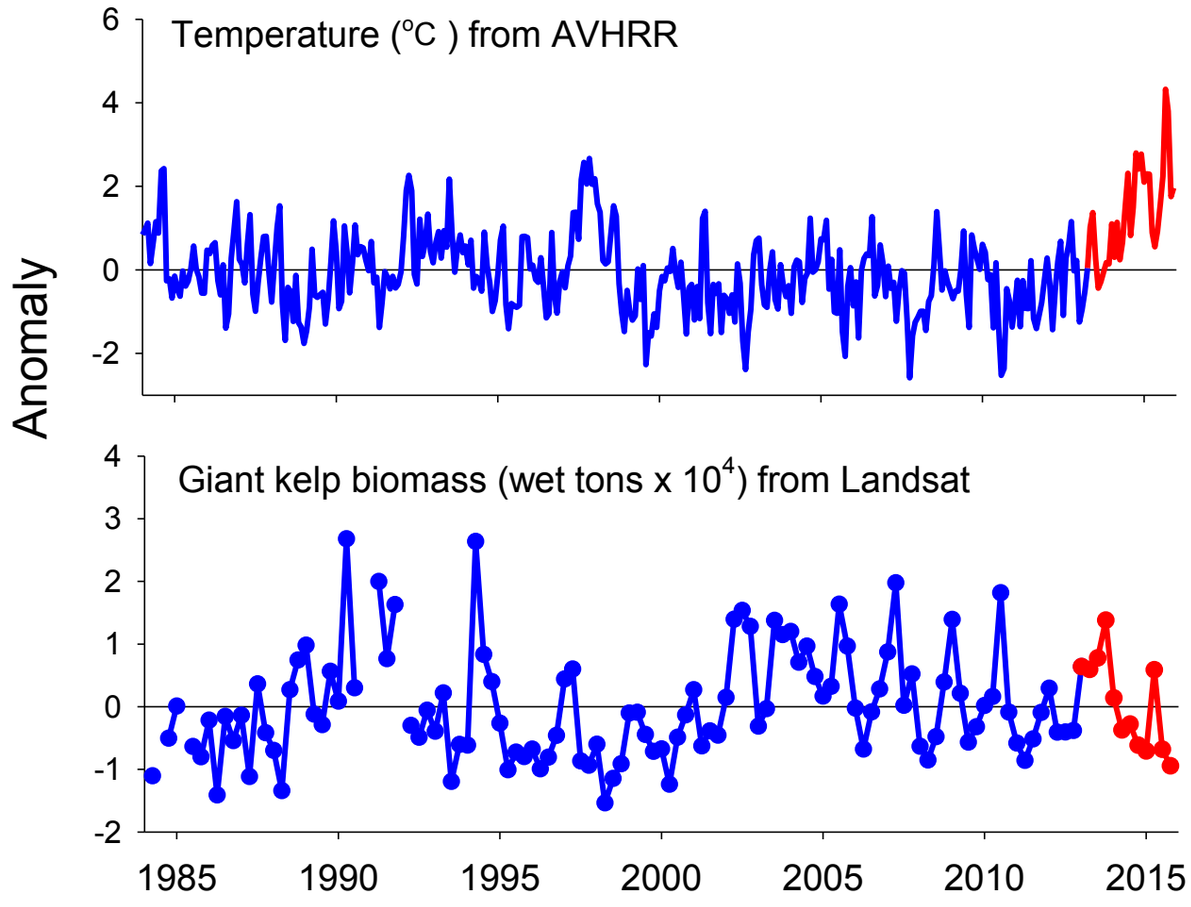


- Biomass of giant kelp and most kelp forest species of macroalgae, invertebrates and fish remained within their historical range in spite of 34 months of extraordinarily warm, nutrient depleted conditions

- Sea stars and sea urchins, key predators and grazers, declined due to disease

Data from satellite imagery used to extend spatial and temporal scales of analyses

Longer & more spatially comprehensive data from satellites confirm the patterns documented by divers and instrumentation at our study sites

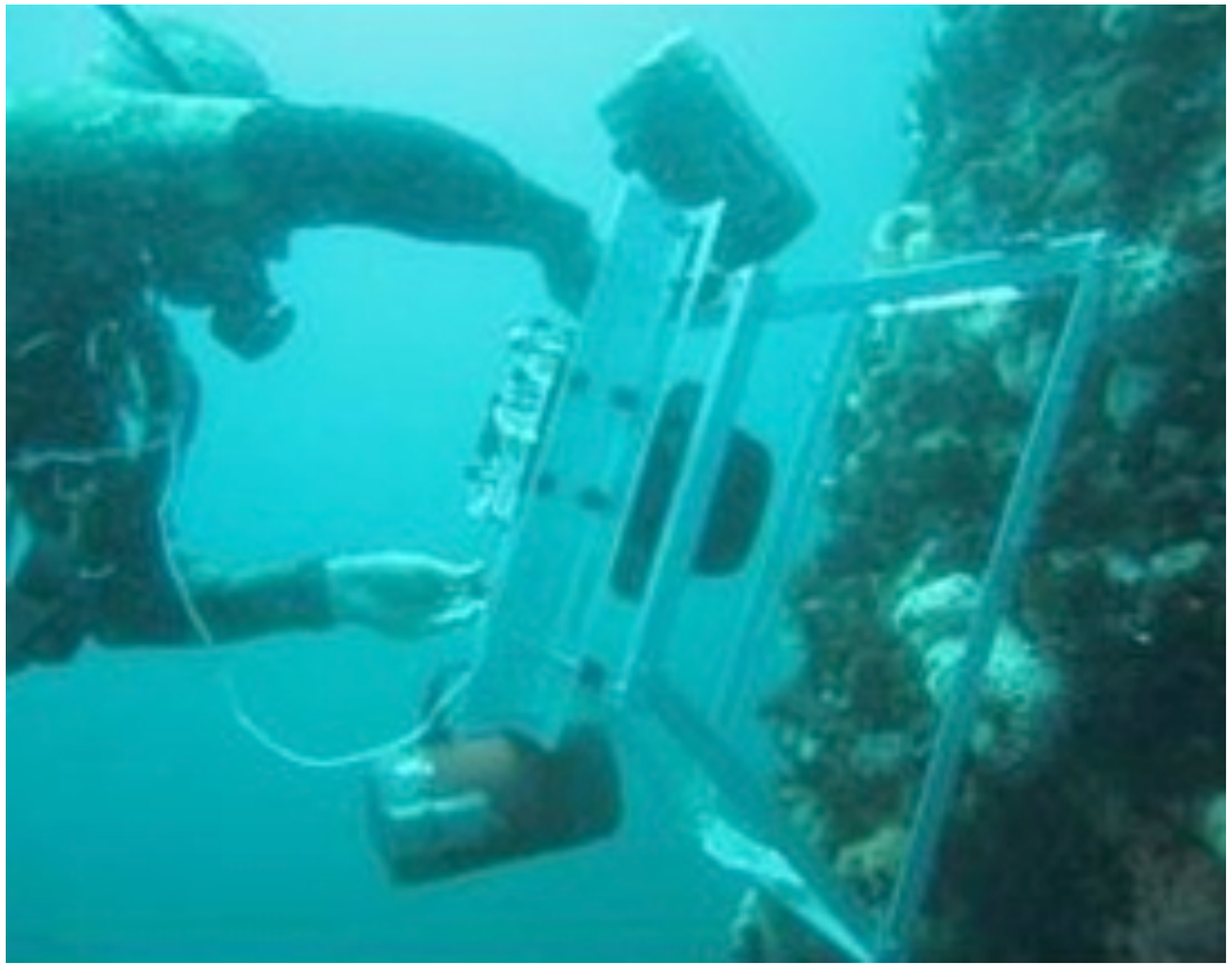


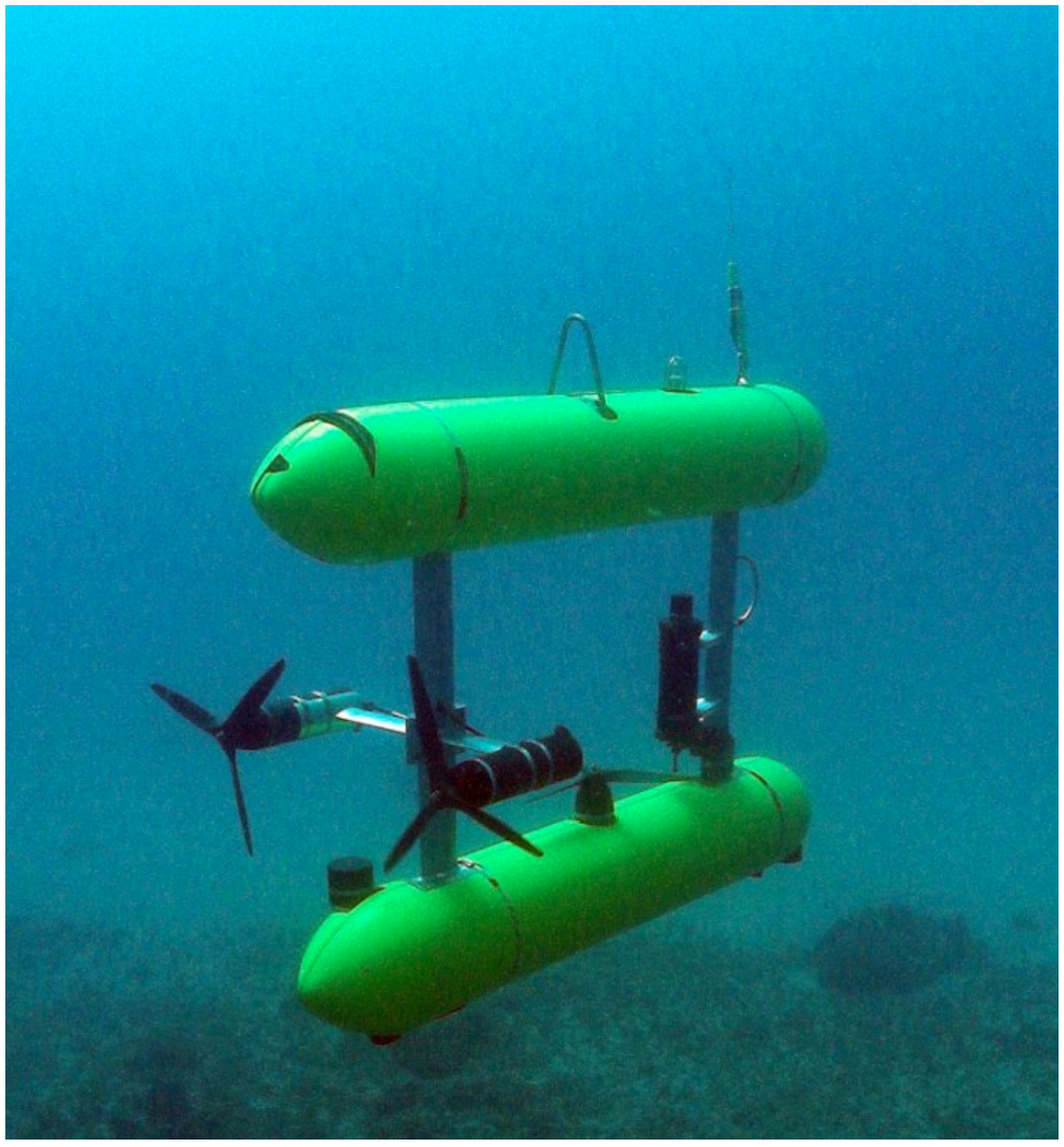
- Results reinforce the need for long-term biodiversity data and expose the risk of relying on species with seemingly sensitive traits as sentinels for ecosystem responses to climate change

Reed et al in review, *Science*

Goal 2. Develop advanced methods in optical and acoustic imaging and genomics for monitoring biodiversity

Optical Imaging





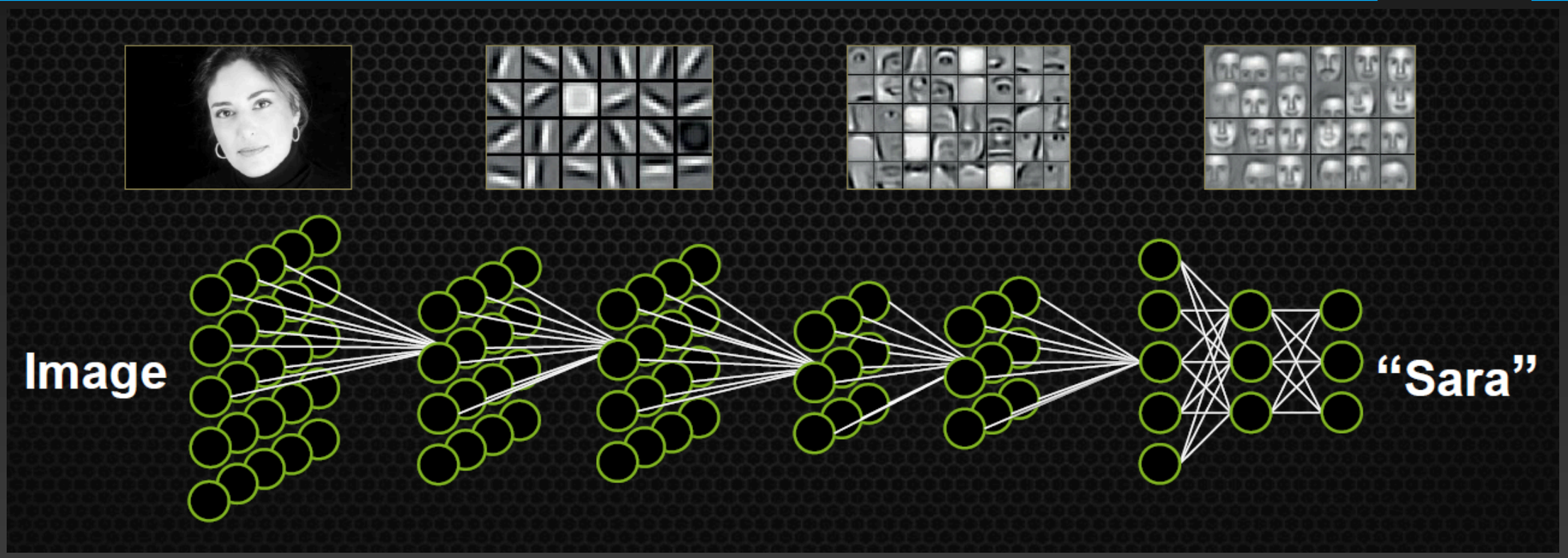
Deep learning for image analysis

UCSB Center for Bio-image Informatics

Benefits

- Fully automated - no feature selection
- Fast classification on GPUs
- High accuracy
- Generalizes to any data

Convolutional Neural Network (CNN)

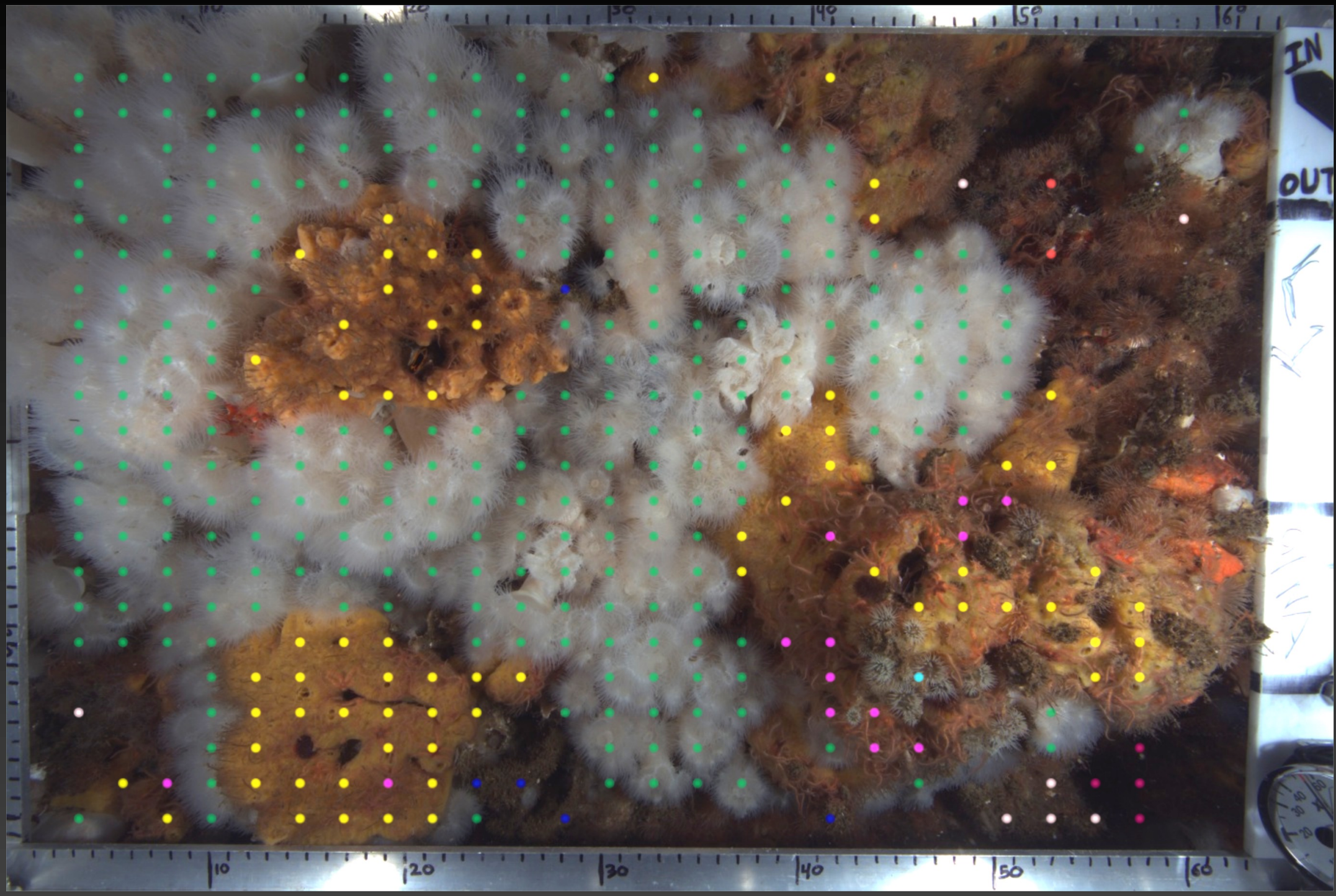


Convolutional levels: Feature extraction typically required an engineer to select or develop a feature descriptor with CNNs it is learned from data.

Classifier: fully connected layers

BisQue

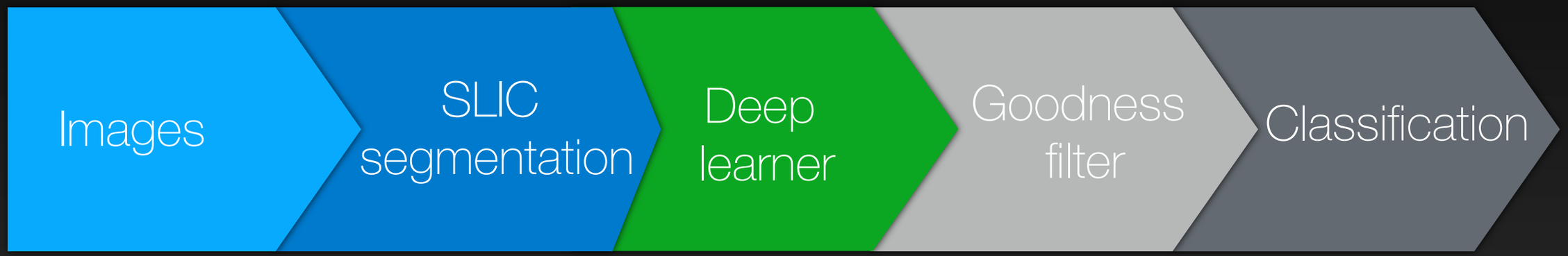
Percent cover at 95% goodness

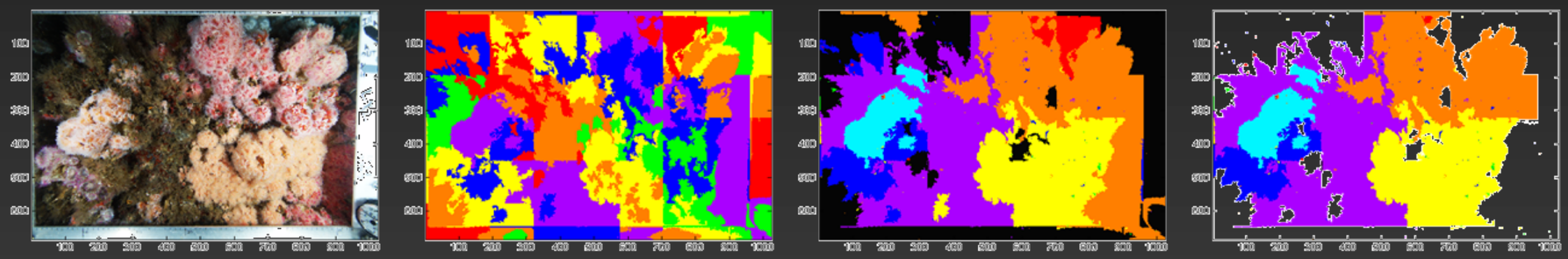


Rahimi et al. 2015

BisQue

Semantic segmentation

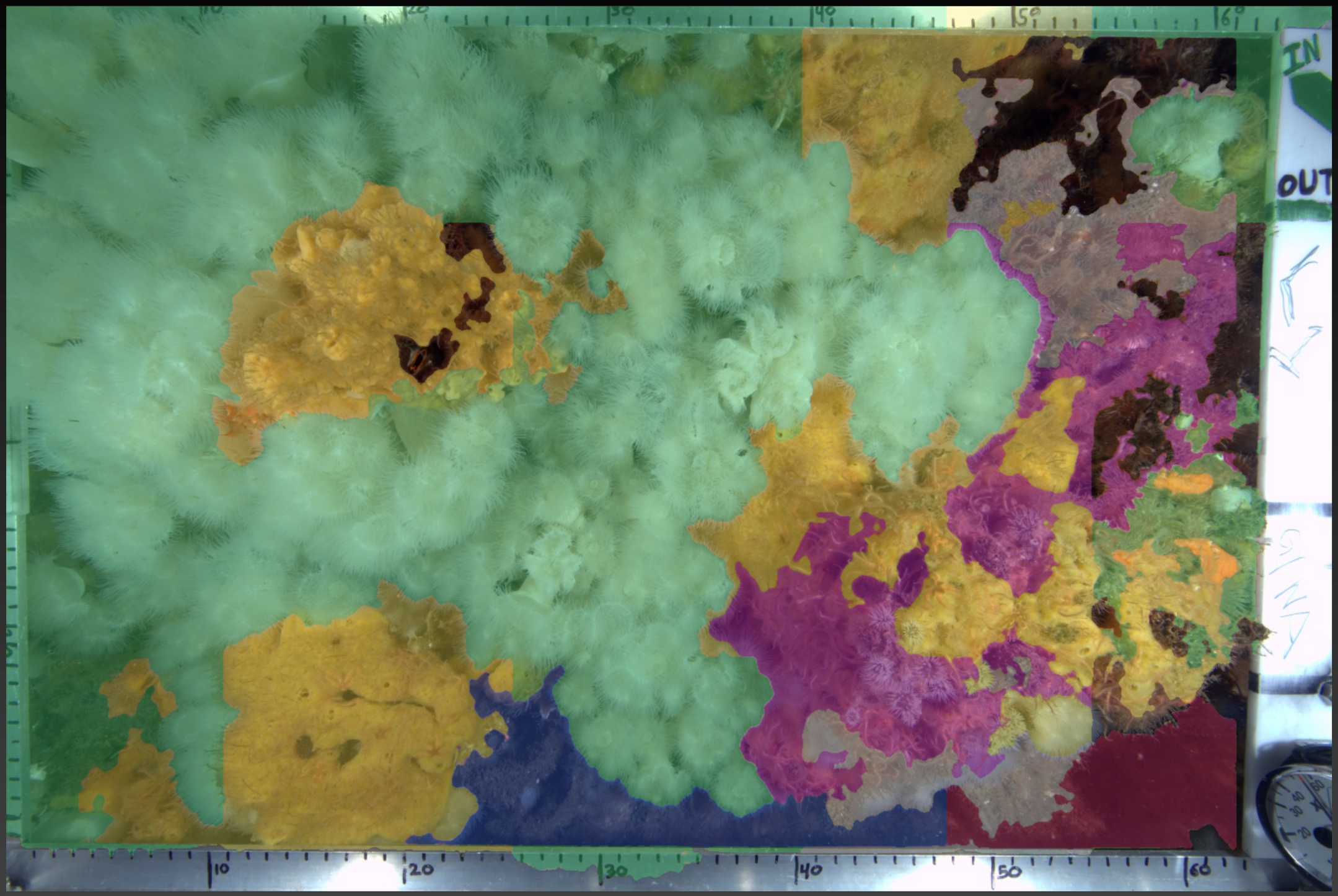




Dmitry Federov, Kris Kivekval, BS Manjunath

BisQue

Segmentation at 95% goodness

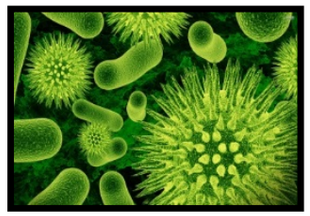


Goal 2. Develop advanced methods in optical and acoustic imaging and genomics for monitoring biodiversity

Ecosystem

Total DNA collected on filters

Amplification of barcode genes for particular groups (prokaryotes to vertebrates)

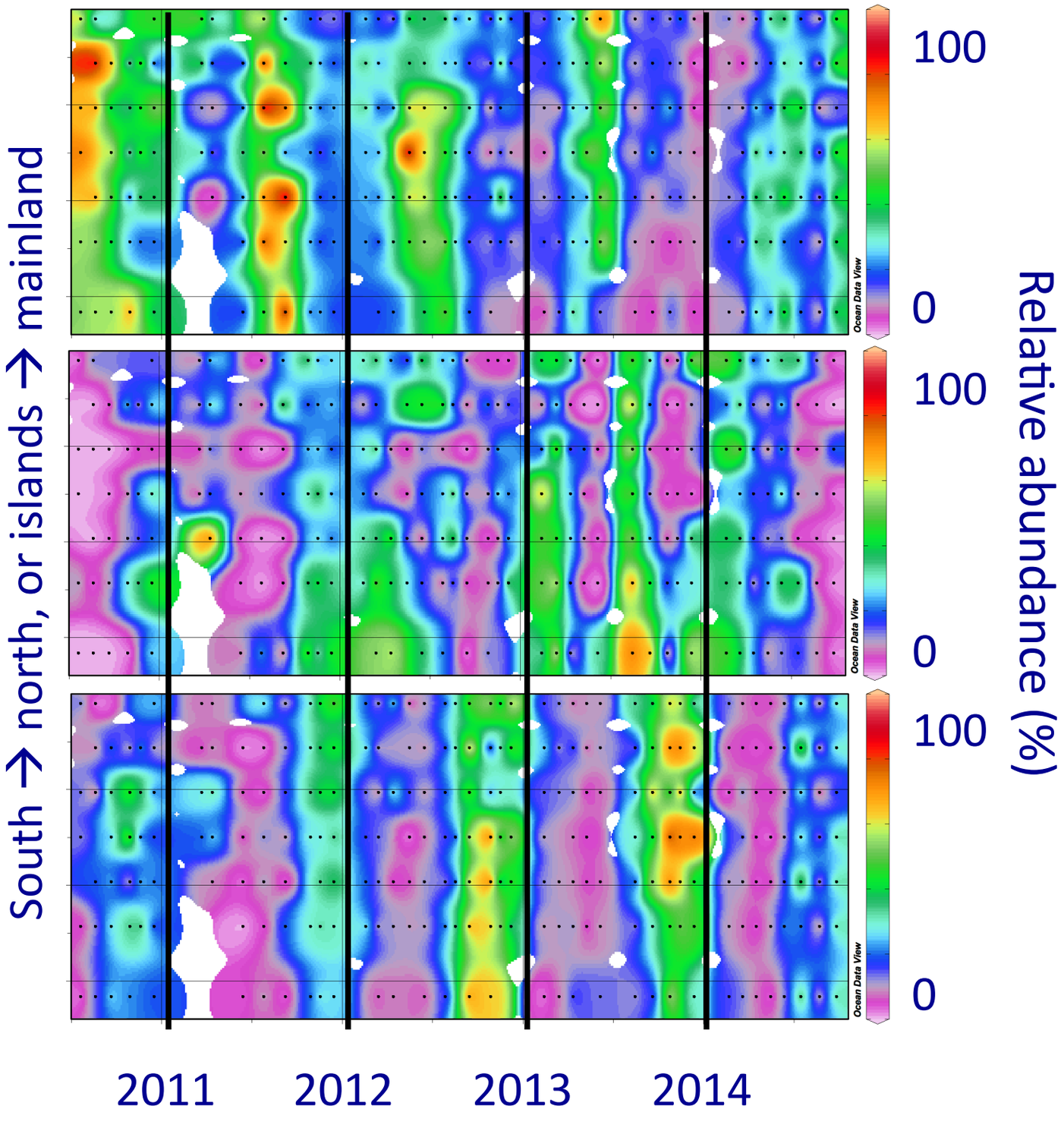


A Genomic View of Biodiversity Across Multiple Trophic Levels

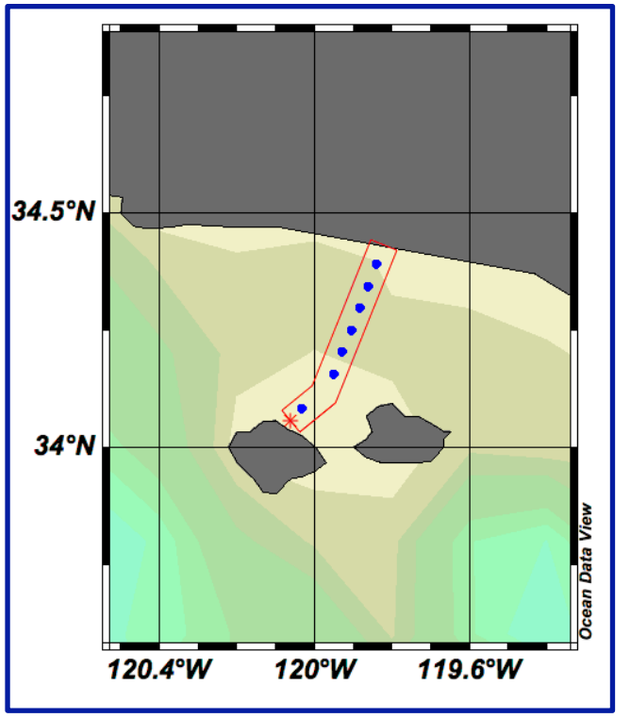
Targets:

- Microbes
- Microplankton
- Ichthyoplankton
- eDNA

Time-series shows repeatable, seasonal surface bacterioplankton communities



- Time-series on Plumes & Blooms cruise line
- 44 cruises, 2010-14
- Profile to 300m at center station
- new Earth Microbiome Project 16S rDNA primers

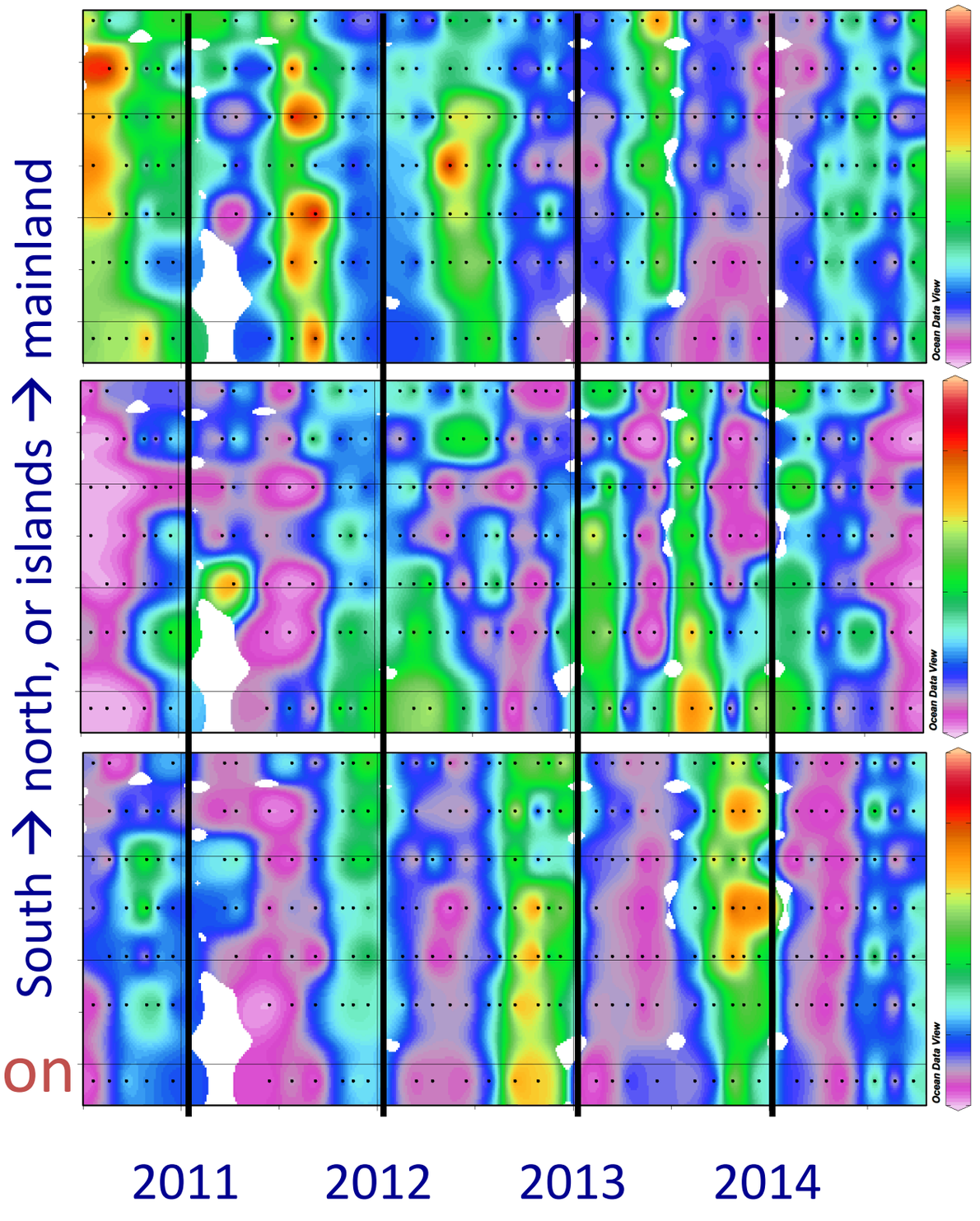


These dominant OTUs have clear, distinct correlations to bottom-up controls

SAR86
Blooms

SAR11
Surface 1
Mixing & upwelling

SAR11
Surface 2
Stratification



Positive Spearman's *rho*:
- Bacterial production
- Phyto biomass
- Diatom indicators

Negative:
- Inorganic nutrients

Positive:
- Inorganic nutrients

Negative:
- [DOC]
- Temperature

Positive:
- Temperature

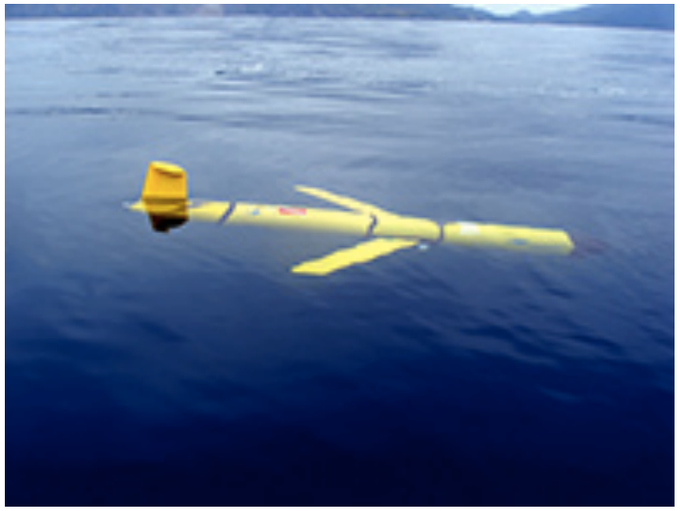
Negative:
- Bacterial production
- Inorganic nutrients
- Phyto biomass

Now comparing 4 primer sets to examine relative biases in this system

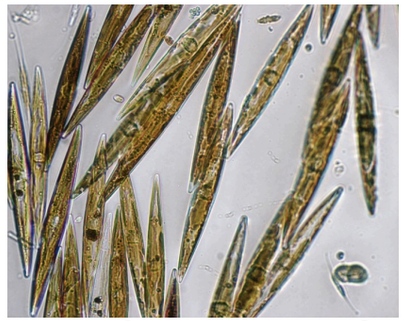
Primer set	Phylogenetic range	16S region	Reference	Why
515F-Y 806R-B	Bacteria & archaea	V4	Earth Microbiome Project; Apprill et al. 2015; Parada et al. 2015	Our existing illumina primer set
27F 338R	Bacteria	V12	Fortunato et al. 2012 (used in Wear et al. 2015)	Our old Roche-454 primer set
341F 785R	Bacteria & (some?) archaea	V34	Klindworth et al. 2012	C. Nelson at UH sees good results
515F-Y 926R	Bacteria & archaea	V45	Parada et al. 2015	Worked well in nearby basin

We are using a site-specific 16S clone mock community of known composition and ~ 90 unique environmental (mixed community) samples to assess the primers

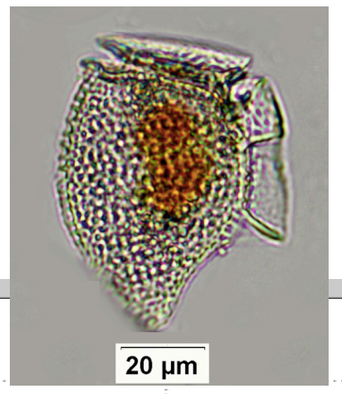
Emma Wear, Craig Carlson

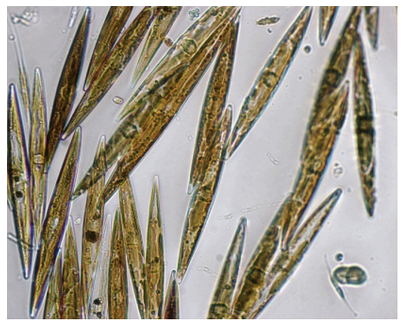


Fernanda Henderikx Freitas
David Siegel, Libe Washburn
Stuart Halewood, Erik Stassinos

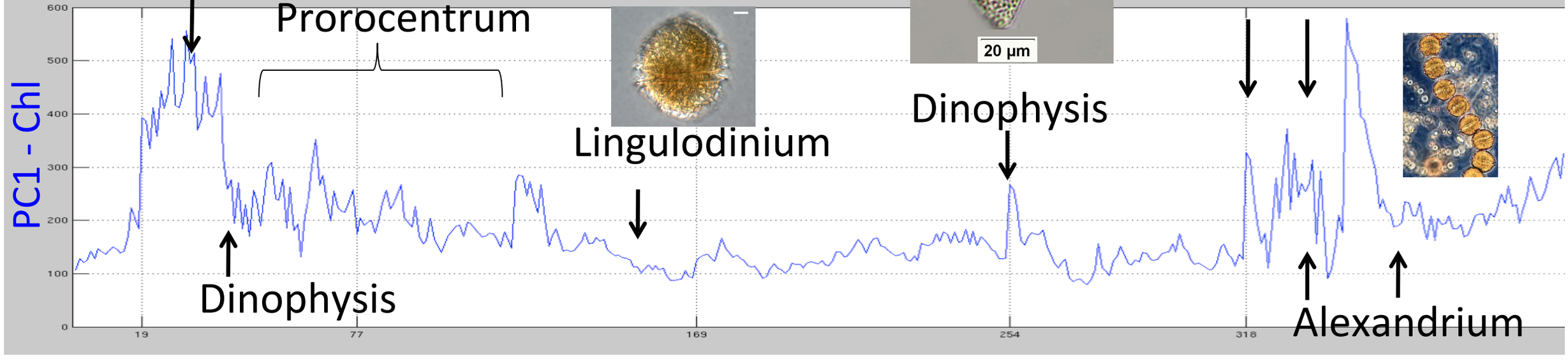


Pseudo-nitzschia





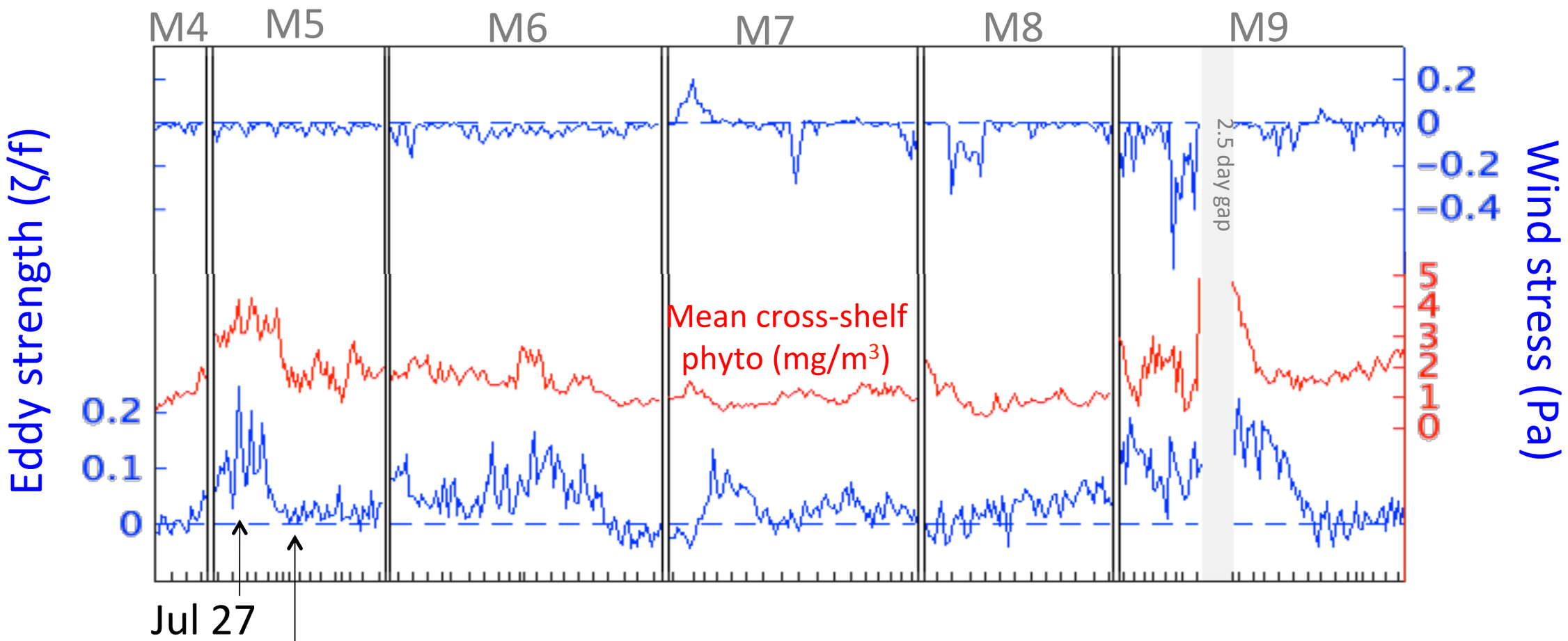
Pseudo-nitzschia

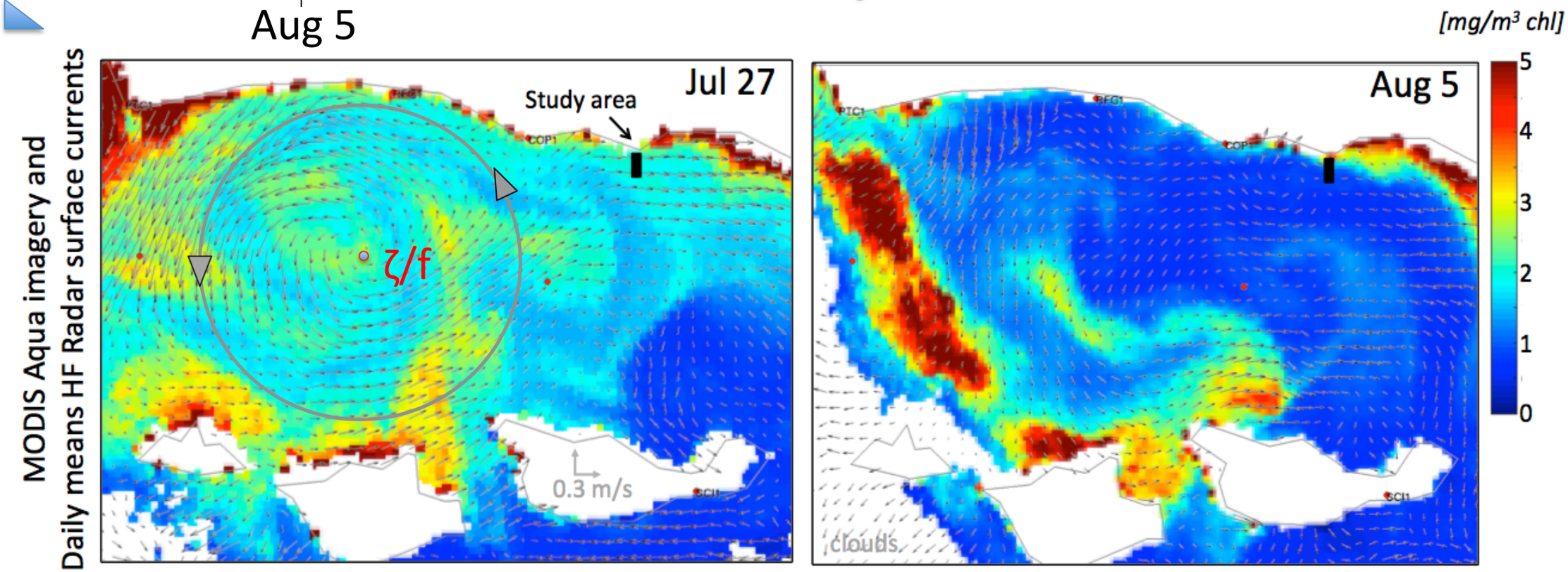


Mar Jul-Aug Sept Nov-Dec Feb June

2012 2013

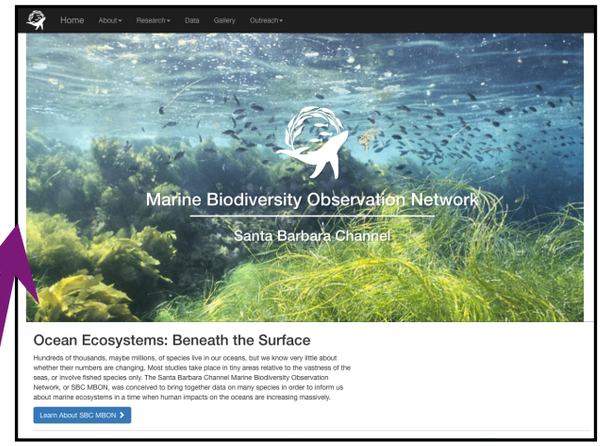
What drives Phytoplankton changes?



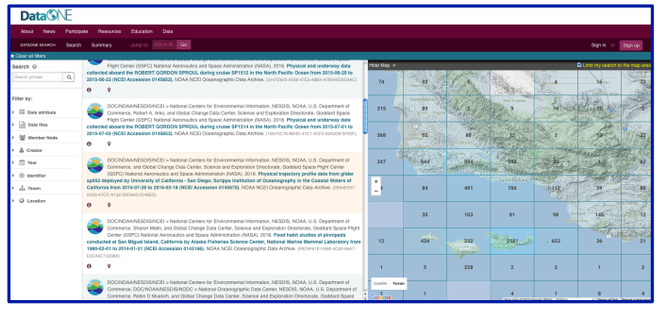


Santa Barbara Channel MBON IMS

- **Adopted community protocols and standards per LTER**
  - **Relational Database Management System -> XML**
  - **Structural quality control**
  - **Local catalog**
- **Federation mechanism – DMAC group**



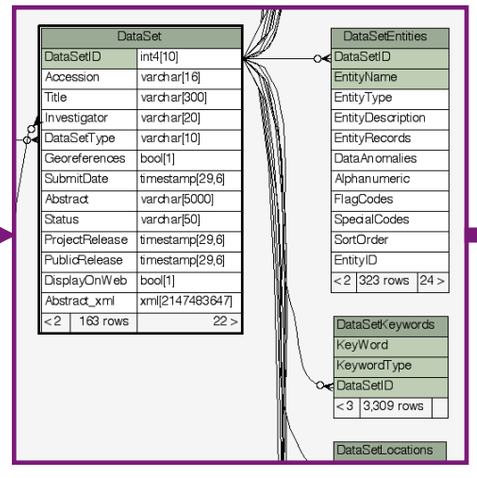
DataONE Member Node?



Servers

Integrate ingested & de novo data

Data Package Design



EML Metadata Export

Data Package Checking

IOOS, Marine Cadastre, NODC, etc.

SBC MBON Partner collaborations

- SCCWRP/NOAA SWFSC
  - Ichthyoplankton metabarcoding postdoc
  - Dovi Kacev started fall 2015

- NOAA NCCOS
  - Spatial linkage of physical habitat variables with biodiversity to improve forecasting ability
  - NCCOS lead Brian Kinlan
  - Rhiannon Rognstad starting Aug 2016